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p 3

measured (lambda/delta lambda) = 620
at K

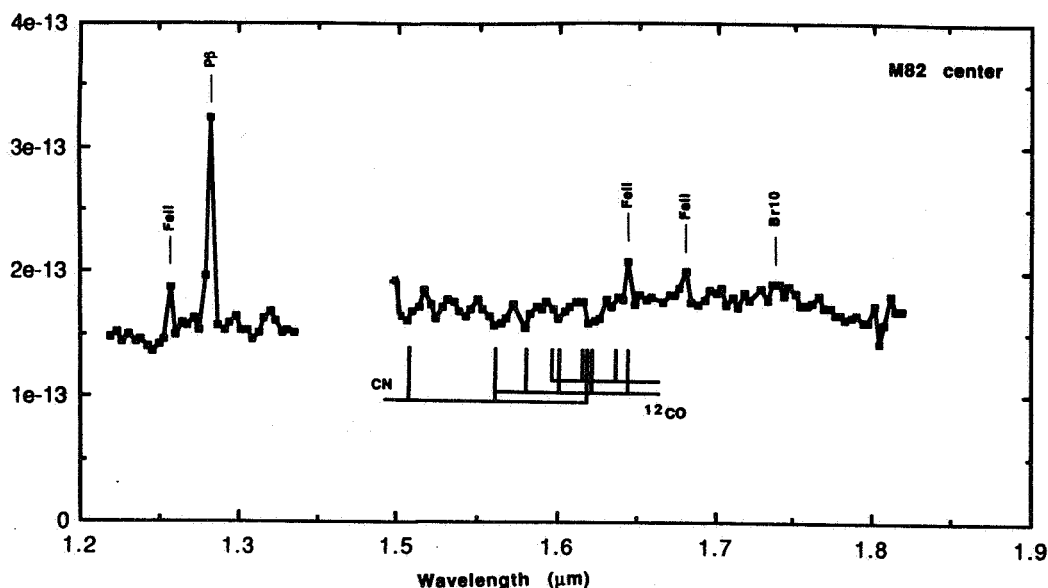
A NEAR INFRARED SPECTROSCOPIC STUDY OF THE INTERSTELLAR GAS IN THE STARBURST CORE OF M82

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Research
We have used the McDonald Observatory Infrared Grating Spectrometer, to complete a program of spatially resolved spectroscopy of M82. The inner 300pc of the starburst was observed with 4" (50pc) resolution. Complete J,H and K band spectra with resolution $0.0035\mu\text{m}$ ($\lambda/\Delta\lambda=620$ at K) were measured at the near-infrared nucleus of the galaxy. Measurements of selected spectral features including lines of FeII, HII and H₂ were observed along the starburst ridge-line, so the relative distribution of the diagnostic features could be understood. This information has been used to better define the extinction towards the starburst region, the excitation conditions in the gas, and to characterize the stellar populations there. A complete discussion of these observations will appear shortly (Lester *et al.*, in press ApJ).

Figures 1 and 2 show the nuclear spectrum, which is rich in absorption and emission lines at this resolution. The CO absorption bands from the cool photospheres in the starburst dominates the infrared spectrum. Brackett γ , Paschen β and FeII are prominently in emission. Figure 3 shows the distribution of several diagnostic features across the starburst ridge-line. The near infrared continuum emission is strongly peaked at the center, while the Brackett γ emission is much more extended. Emission in the 1-0 S(1) line of H₂ is detected in the starburst region. Figure 3 shows that this line is not coextensive with either the continuum emission or the ionized gas, but extends well beyond them into the molecular 'ring' that surrounds the starburst. These three spectral diagnostics have been observed in a number of more distant starburst or interacting systems. The spatial inhomogeneity that we find among these diagnostics in M82 should caution us against using simple aggregate models for understanding the more distant, spatially unresolved galaxies.



Figures 1: J, H band spectra of the nucleus of M82

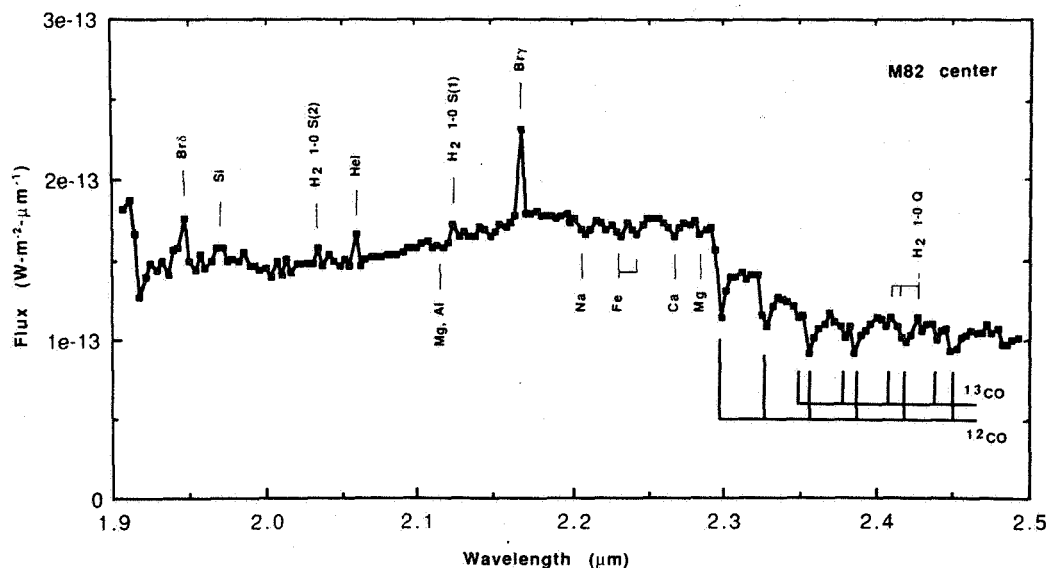


Figure 2: K band spectrum of the nucleus of M82

We find that the excitation of the H₂ emission in M82 is due to shocks. While the strong continuum at the nucleus makes it difficult to see other H₂ lines there (the stellar absorption features on which the lines are superimposed are more of a problem than is the small line-to-continuum ratio!) the very different spatial distribution of the H₂ and continuum allows us to see them elsewhere. Figure 4 shows a piece of spectrum taken 16'' away from the nucleus. At this position, the stellar continuum emission has fallen away substantially, leaving behind the 1-0 S(0) and 2-1 S(1) lines of H₂. The ratio of these lines indicates an excitation temperature of 1500-2000K, which is easily reconcilable with shocked regions in our own galaxy (*e.g.* Hollenbach and Shull 1977). A simple morphological interpretation of distribution of H₂ emission is that it surrounds the starburst. The H₂ emission can thus not be associated with individual star forming regions, but must be excited globally, on the scale of the starburst. The supernova driven wind that is known to be expelling material along the poles of the starburst disk may excite this emission.

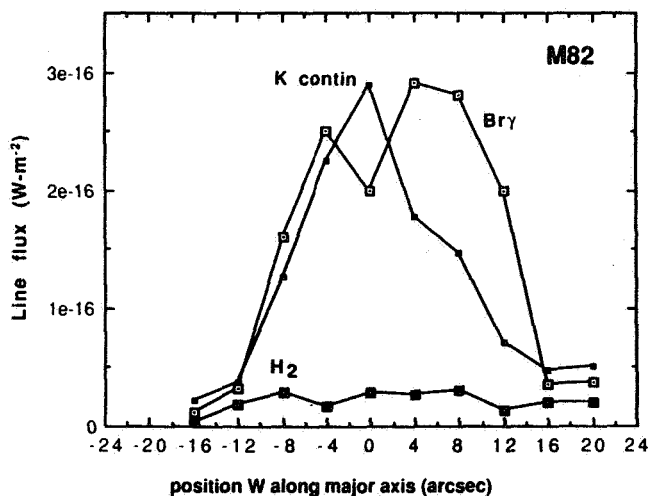


Figure 3: Distribution of 2μm continuum, Brackett γ, and H₂ along the starburst ridge.

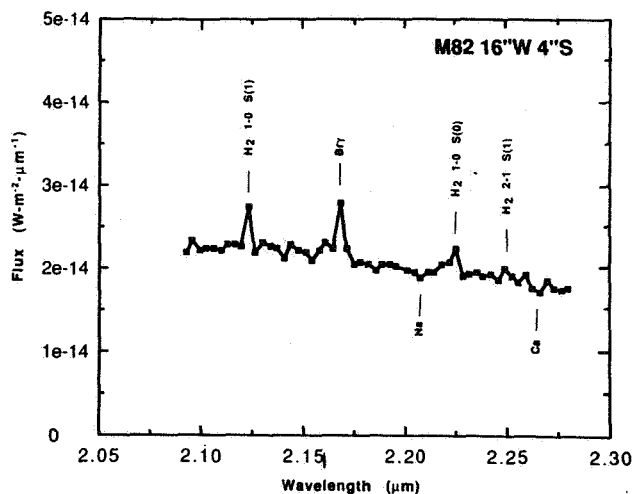


Figure 4: Spectrum of H₂ away from the continuum peak in M82

Emission in FeII 1.644 μ m is distributed more similarly to that of the ionized gas than anything else in our spectra. This line has been found to be especially strong in supernova remnants in our galaxy, where iron abundances have been increased by wholesale destruction of grains. (Graham *et al.* 1986). It is thus not surprising that the distribution of this line in M82 is similar, in general, to the distribution of the massive stellar progenitors of these supernovae. There is some evidence (in the lack of a 'hole' at the center, and enhanced emission over Brackett γ on the eastern edge of the starburst core) that FeII is distributed somewhat more like the nonthermal radio emission, however (see Figure 5). This distinction makes the origin of the FeII in supernova remnants even more attractive. The lack of perfect correspondence between SNRs and massive stars can be understood in terms of non-coeval formation of individual massive stellar clusters in the galaxy.

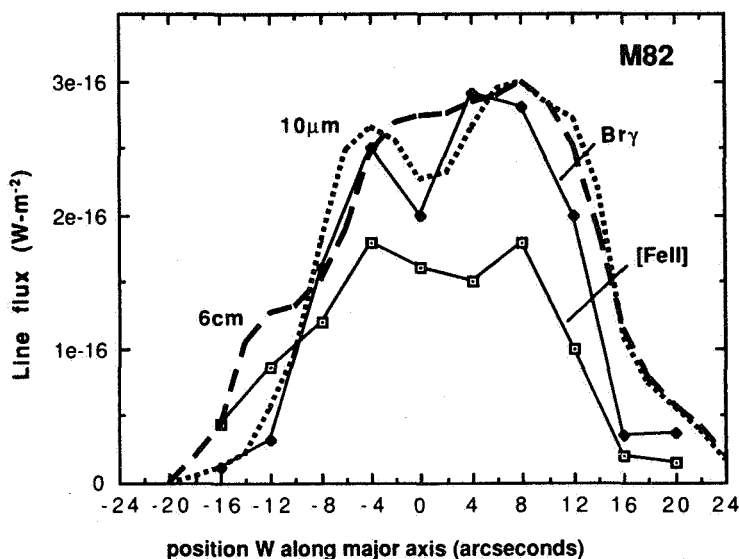


Figure 5: Distribution of radio and 10 μ m thermal emission is compared with that of Brackett γ and FeII along the starburst ridge line.

Four hydrogen recombination lines in the 1-2.2 μ m part of the spectrum give an extinction corresponding to $A_v=5.4$ at the nucleus. This extinction curve predicts an H α flux that agrees precisely with that which is observed (O'Connell and Magnano 1977), and is consistent with estimates of the thermal component of the radio emission. Larger extinction estimates based on Brackett α need to be reexamined in light of the internal consistency of these measurements. The larger extinction that is derived from the 9.7 μ m 'silicate' feature probably corresponds to those denser regions that produce most of the 10 μ m continuum emission. Application of this small extinction to the starlight from the nucleus of M82 yields a K band luminosity that can be reconciled with the dynamical mass in the nucleus with a normal IMF. The amount by which the 2 μ m starlight should be corrected for extinction is probably the single most important issue facing our understanding of stellar populations in the starburst region (Rieke *et al.* 1980).

Graham, J.R., Meilke, W.P.S., Allen, D.A., Longmore, A.J., and Williams, P.M. 1986 *M.N.R.A.S.* **218**, 93.

O'Connell, R.W. and Magnano, J.J. 1977 *Ap.J.* **221**, 62.

Hollenbach, D.J., and Shull, J.M. 1977 *Ap.J.* **216**, 419.

Rieke, G.H., Lebofsky, M.J., Thompson, R.I., Low, F.J., and Tokunaga, A.T. 1980 *Ap.J.* **238**, 24.